

CHALLENGES OF SAFAR- OPERATIONAL AIR QUALITY FORECASTING SYSTEM FOR INDIAN METROS



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***India Meteorology Department, New Delhi**





System of Air Quality and Weather Forecasting and Research (SAFAR-India)



ISO 9001:2008 Accredited by Standard Certification Council-India
GURME, World Meteorological Organization Piloted

Metropolitan Air Quality & Weather Services

IITM and IMD

ESSO, Ministry of Earth Sciences, Govt. of India

VISION

SAFAR -OBJECTIVES

**SYSTEM
DEVELOPMENT**

**SCIENTIFIC
RESEARCH**

**Weather
Information
Services**

**Air Quality
Information
& Advisory**



PRODUCTS -Citizens

**Impacts:
Health &
Agriculture**

**Innovative
Science
Issues**



PAPERS -Scientists

SAFAR Mission

“System of Air Quality, Weather Forecasting & Research”

Operational Air Quality Forecasting System for India Metros

Novel program of Govt. of India

MISSION GOAL

Development of early warning system for **Air Quality, Weather & UV related information**, its **up to 3 day advance forecast** and **associated advisories** for the benefit of society.

CITIES DONE 2010-2015

DELHI (2010), PUNE (2013), **MUMBAI** (2015)

CITIES TO BE DONE 2015-2017

AHMEDABAD, CHENNAI, KOLKATA

 Operational

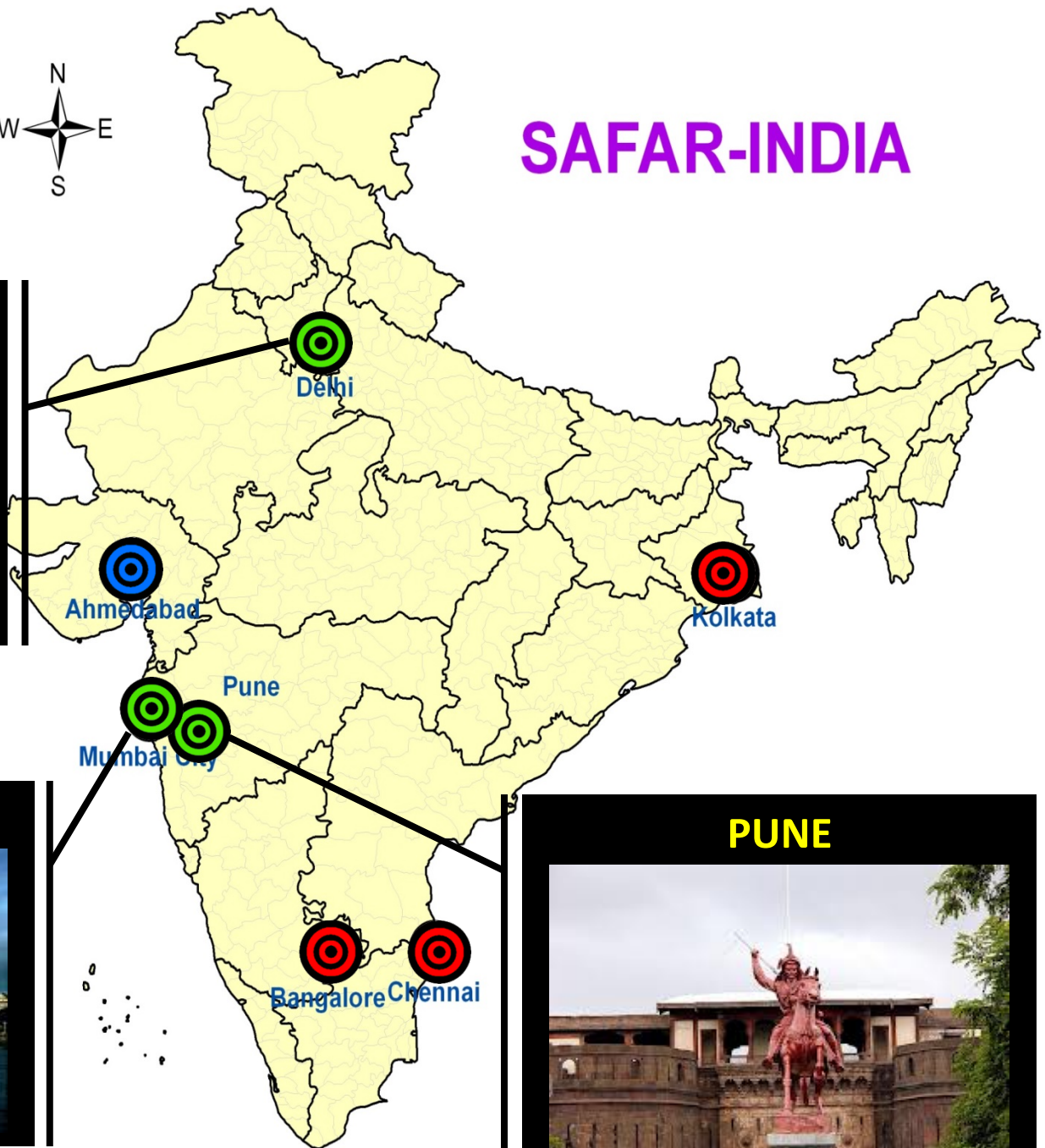
 Ongoing

 Upcoming



SAFAR-INDIA

DELHI



MUMBAI



PUNE



SAFAR- SYSTEM COMPONENTS

1

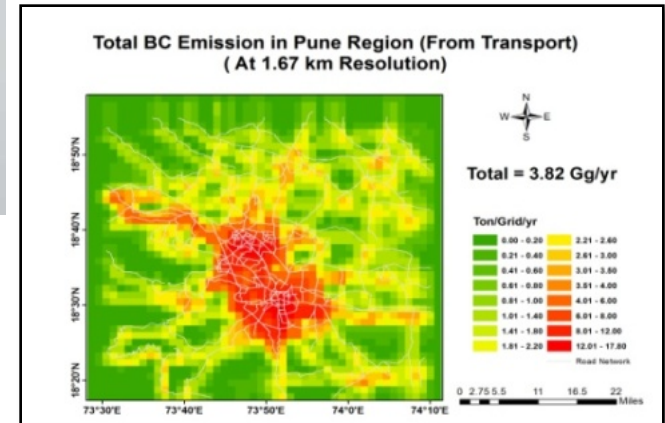
OBSERVATIONAL NETWORK



Air Quality & Weather Monitoring

2

EMISSION INVENTORIES



Accounting sources of pollution

3

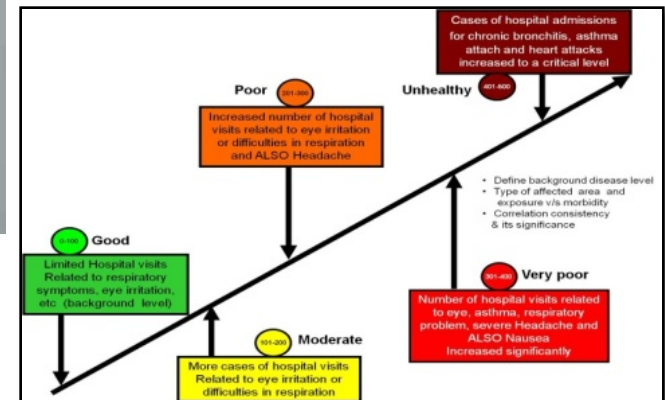
FORECASTING MODEL



Air Quality & Weather Forecasting

4

COMMUNICATION MEDIA



Translate Data in to Information

SAFAR-India: FOUR CORE COMPONENTS

OBSERVATIONAL NETWORK



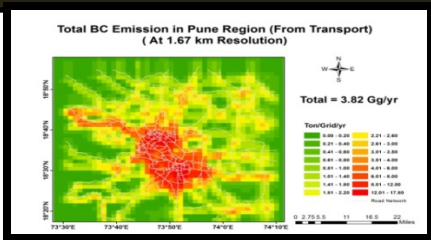
Monitor Air Quality & Weather Parameters at strategically selected locations

PM₁₀, PM_{2.5}, PM₁, O₃, CO, NO_x, CH₄, VOCs, SO₂, BC, Hg, Rainfall, Temperature, Humidity, Wind speed, Wind direction, UV Radiation

EMISSION INVENTORIES

Accounting sources of pollution

Identify air pollution hot spots over city, crucial input for forecasting model



FORECASTING MODEL

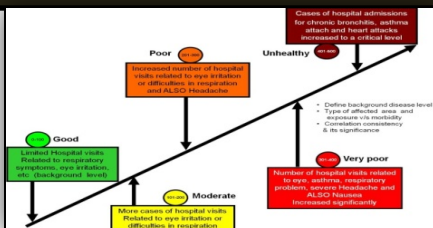


Develop capacity to predict air quality 1 to 3 days in advance

OUTREACH

Convert science in to Information

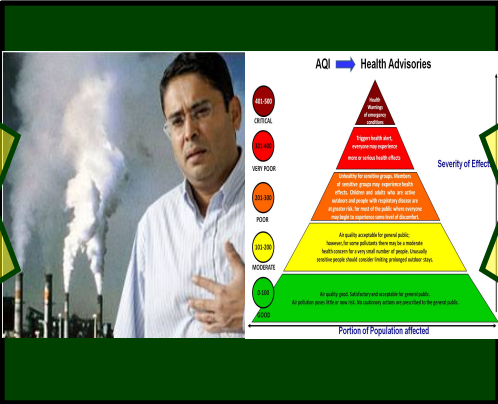
Developed concept of Air Quality Index (AQI) and UV Index (UVI)



SAFAR- INFORMATION PRODUCTS



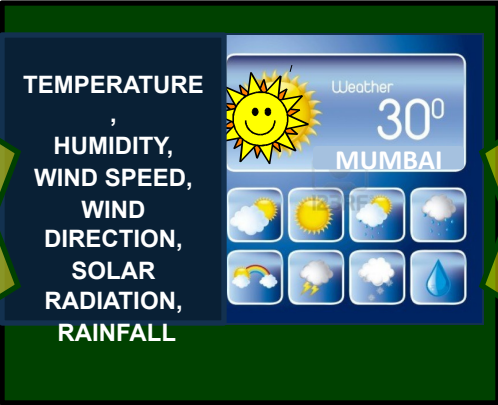
**AIR QUALITY
- RELATED
HEALTH
ADVISORIES**



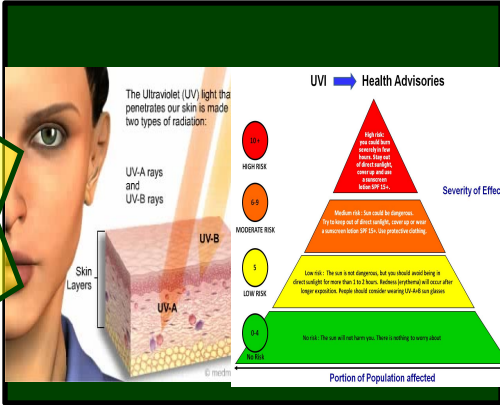
***HIGH TIDES/
LOW TIDES***



***WEATHER
CONDITIONS***



**SUN'S
HARMFUL
RADIATION
(UVI) & SKIN
ADVISORIES**



**LOCATION
SPECIFIC
EXTREME
POLLUTION
& WEATHER
WARNING**



***EDUCATIONAL
SLOGANS***

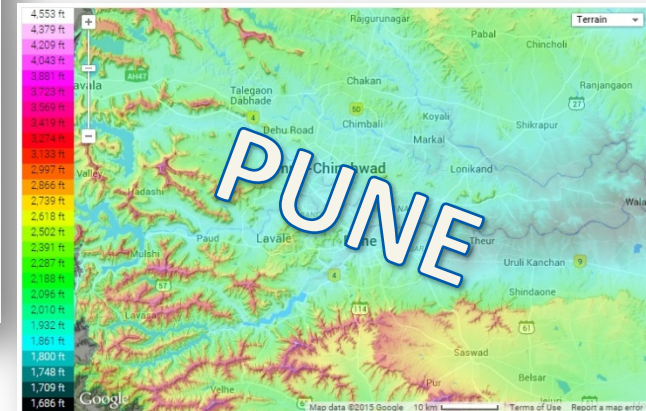


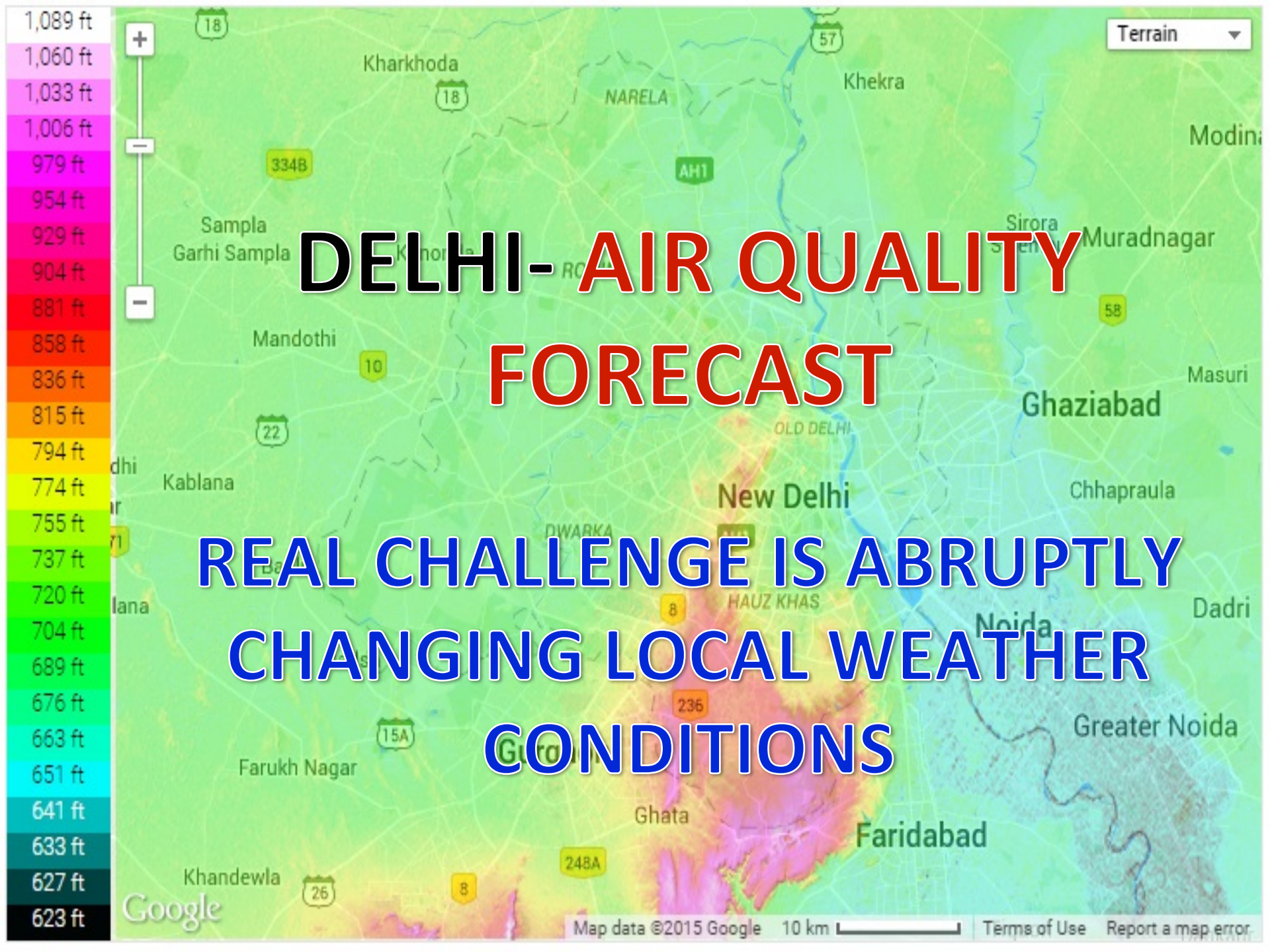
SAFAR SYSTEM DEVELOPMENT FOR METROPOLITAN REGIONS

CHALLENGE

1. Practical
2. Technical
3. Scientific

- DIFFERENT METEOROLOGICAL CONDITIONS
- DIFFERENT TOPOGRAPHY
- DIFFERENT SOCIOECONOMIC STATUS
- VARIOUS MICROENVIRONMENTS
- DIFFERENT EMISSION SOURCES



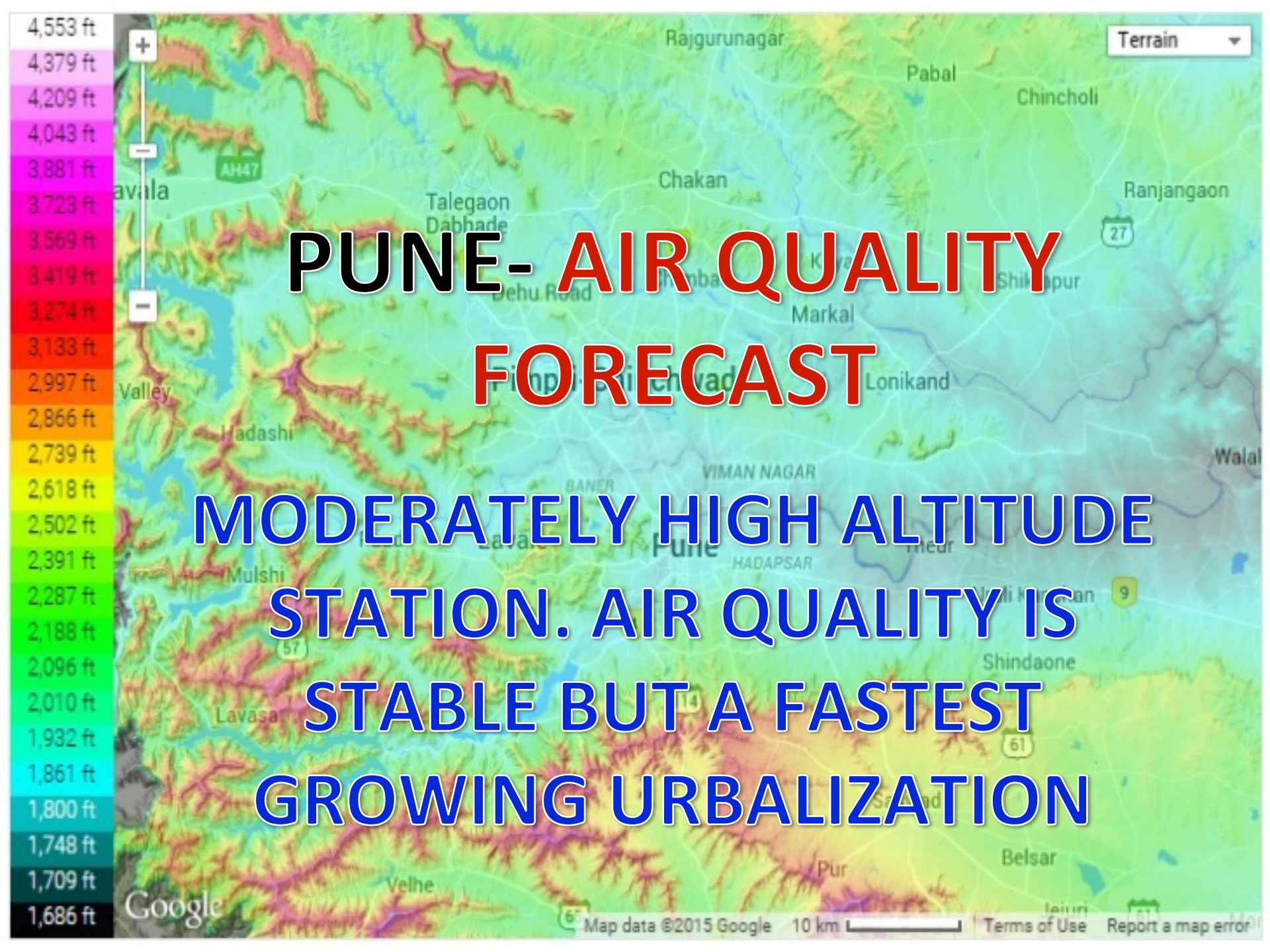


1,089 ft
1,060 ft
1,033 ft
1,006 ft
979 ft
954 ft
929 ft
904 ft
881 ft
858 ft
836 ft
815 ft
794 ft
774 ft
755 ft
737 ft
720 ft
704 ft
689 ft
676 ft
663 ft
651 ft
641 ft
633 ft
627 ft
623 ft

DELHI-AIR QUALITY FORECAST

REAL CHALLENGE IS ABRUPTLY
CHANGING LOCAL WEATHER
CONDITIONS

Google

A topographic map of the Pune region in India, showing various towns and roads. A vertical altitude scale on the left side ranges from 1,686 ft to 4,553 ft in increments of 100 ft, with color-coded bands. The map includes labels for towns like Rajgurunagar, Pabal, Chincholi, Ranjangaon, Chakan, Talegaon Dabhade, Markal, Lonikand, Hadashi, Mulshi, Lavasa, Velhe, Pur, Belsar, and Shindane. Roads are marked with numbers like 27, 9, 61, 57, 14, and 6. The text 'PUNE- AIR QUALITY FORECAST' is overlaid in large, bold letters. Below it, another text block describes the station and urbanization trends. The Google logo is visible in the bottom left corner, and map data information is at the bottom.

PUNE- AIR QUALITY FORECAST

MODERATELY HIGH ALTITUDE
STATION. AIR QUALITY IS
STABLE BUT A FASTEST
GROWING URBALIZATION



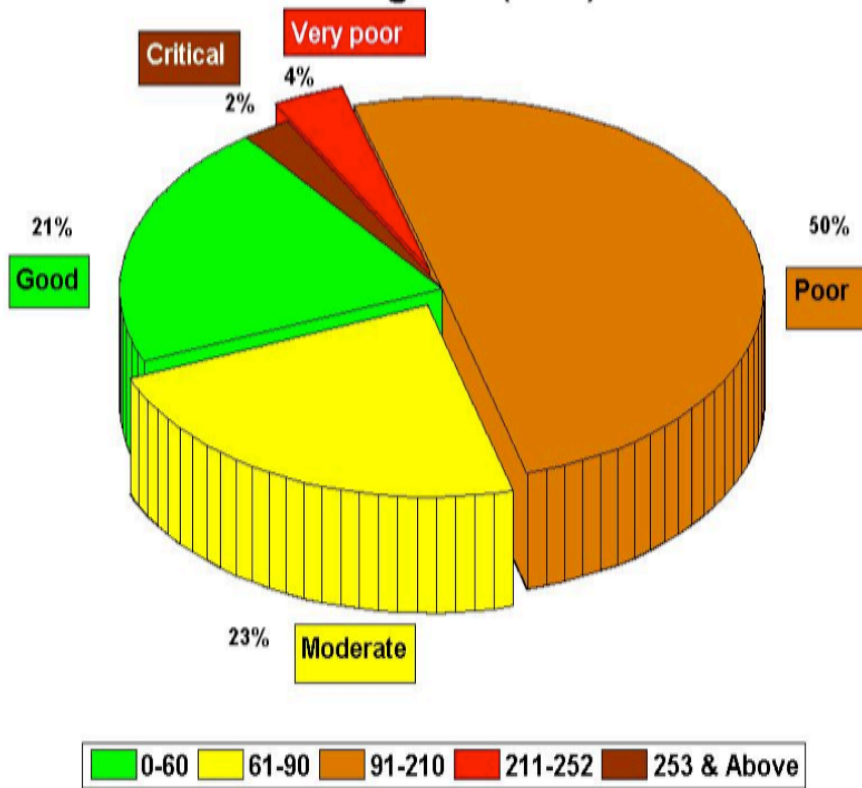
The background is a topographic map of Mumbai and its surrounding regions, including Mira Bhayandar, Bhiwandi, Kalyan, Badlapur, and Navi Mumbai. The map uses a color gradient to represent elevation, with higher elevations in shades of red and yellow, and lower elevations in shades of green and blue. A vertical elevation scale on the left side of the map ranges from -12 ft to 2,631 ft, with major increments every 100 ft. The map includes labels for various locations, roads, and geographical features like the Vasai Creek. At the bottom, there is a Google logo, a scale bar indicating 10 km, and links to 'Map data ©2015 Google', 'Terms of Use', and 'Report a map error'.

MUMBAI-AIR QUALITY FORECAST

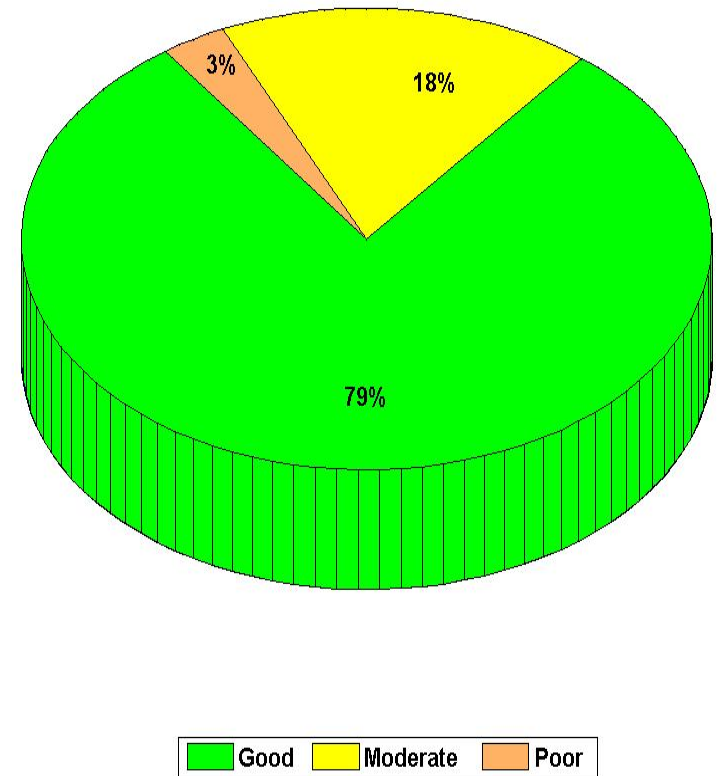
BEING A COSTAL REGION ITS
AIR QUALITY GET INFLUENCED
BY SEA BREEZE

AIR QUALITY (PM2.5): DELHI v/s PUNE

DELHI



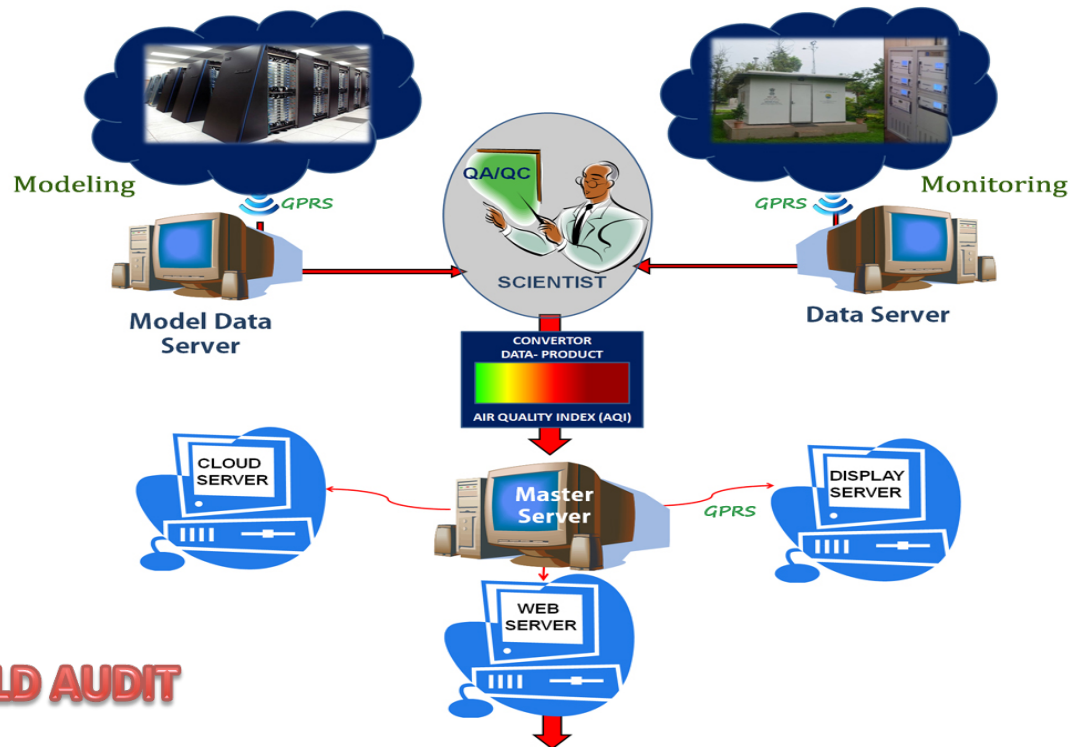
PUNE



A CRITICAL AUDIT PROTOCOL- QUALITY CONTROL AND QUALITY ASSURANCE

It is an essential step performed by the scientist of IITM before releasing the air quality data to public

- ◆ **NON-SCIENTIFIC AUDIT:** FULL SYSTEM BY EXTERNAL AGENCY -ISO
- ◆ **TECHNICAL AUDIT:** INSTRUMENTAL HEALTH AND CUMMUNICATION
- ◆ **SCIENTIFIC QA & QC:** OPERATIONAL SAFAR TEAM OF SCIENTISTS



◆ **ECONOMIC YIELD AUDIT**

AIR QUALITY INFORMATION FOR PUBLIC WITH HEALTH ADVISORIES

SITE SELECTION: IDENTIFY MICRO ENVIRONMENT



INDUSTRIAL AREA



AIRPORT SITE



URBAN COMPLEX

Strategic Observational Network

**Air Quality Monitoring
Weather Monitoring**



RESIDENTIAL AREA



SLUM AREA



ROAD SIDE



BACKGROUND

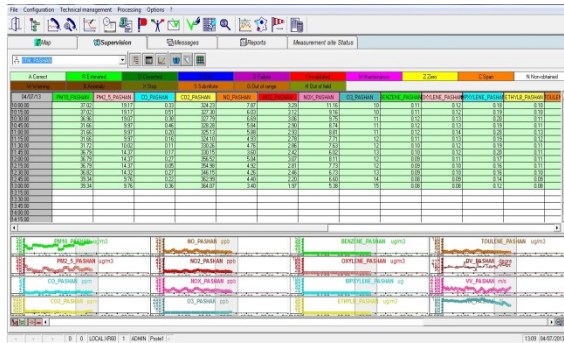


TRAFFIC JUNCTION

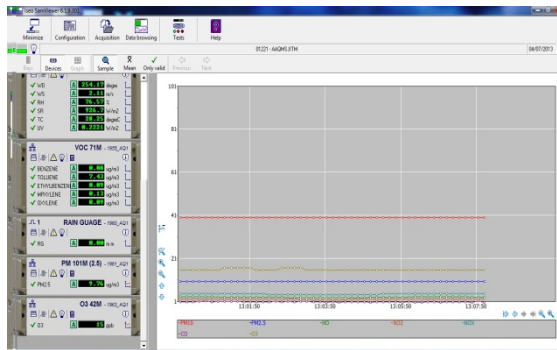


**AGRICULTURAL
AREA**

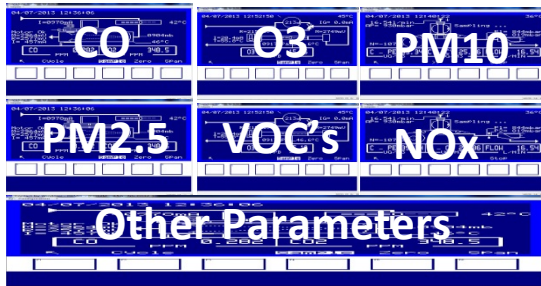
OBSERVATIONS: Data Quality Control & Quality Check



Applying Quality Code



Per second data



Analyzers

Quality codes

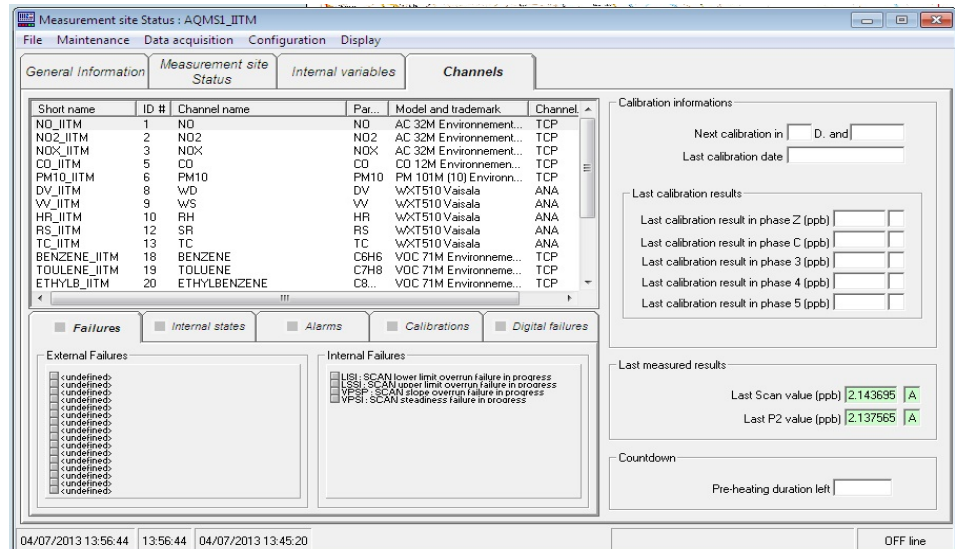
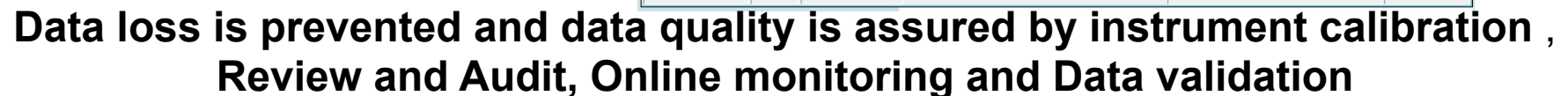
A data is build of a value and a quality code.
 The value comes from the physical measurement.
 The quality code is set to the measurement by the acquisition system according to information relating to the state of the sensor or measurement, but it may be modified by the operator according to information provided by the system.
 The quality codes managed by the application are described in the following table:

Code	Name	Origin	Explanation
A	Usable	Acquisition System	Data considered to be usable without any reserve.
O	Corrected	Operator	Modification of the value by action of the operator.
R	Reconstituted	Operator	Entry or recalculation of the value by action of the operator.
P	In Drift	Acquisition System	On observation of a drift at the end of an operation of calibration.
W	Warning	Acquisition System	On detection of conditions questioning the quality of data. This code is present only on not validated data. After validation, it is replaced by the code A (Usable).
B	Anomaly	Acquisition System	When a part of scans, lower than the rate of representativeness, is absent. This code is present only on not validated data. After validation, it is replaced by the code A (Usable).
I	Invalid	Operator	Data considered as invalid, following checking.
D	In Failure	Acquisition System	On detection of a faulty material operation.
M	In Maintenance	Acquisition System / Operator	By indication of an on site operator.
Z	In Zero	Acquisition System	For the data gathered during a calibration zero phase.
C	In Span	Acquisition System	For the data gathered during a calibration span phase.
N	Not Acquired	Central System	For data not yet acquired.
X*	Stop	Acquisition System	For data acquired during a period where the process is stopped. When 33% of the average is in Stop, the mean will be in Stop. This code is only available by data over encoding.
V*	Stand-by	Acquisition System	In case of equipment in stand by.
G*	Out of range	Acquisition System	Data out of analyzer range.
H*	Out of field	Acquisition System	Data out of QAL2 validity field.

*Available for system SAM 6.0 and more
 Data coded A, O, R, P, W or B are considered as valid and thus usable for calculations, diffusion, or utilisation by alert engines.
 All other data is not used.

WorkStation v 6.1 et 6.2 @iséo vendredi 15 mars 2013

Identification of Problem on time : Assure data quality



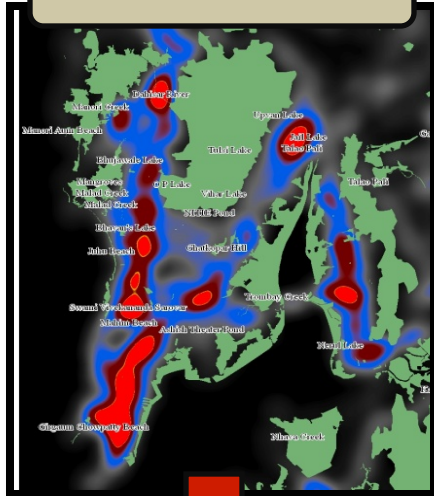
EMISSION INVENTORY DEVELOPMENT

Identification of sources, generating unavailable data involves extensive field survey

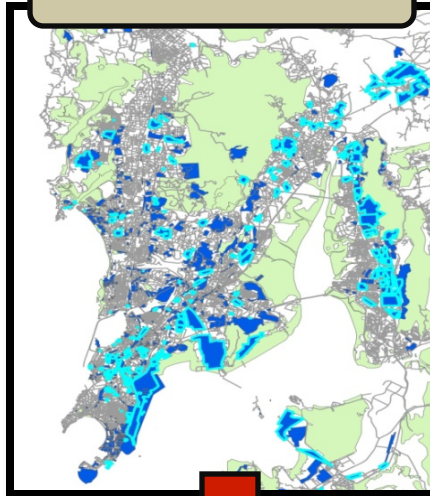
EMISSION INVENTORY Mega Campaign

Efforts of more than 200 students – to collect unique region specific dataset

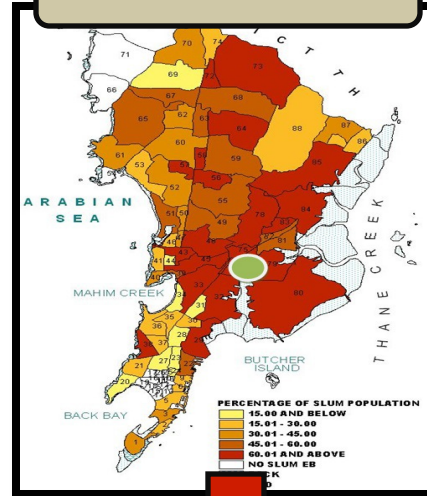
TRANSPORT SECTOR



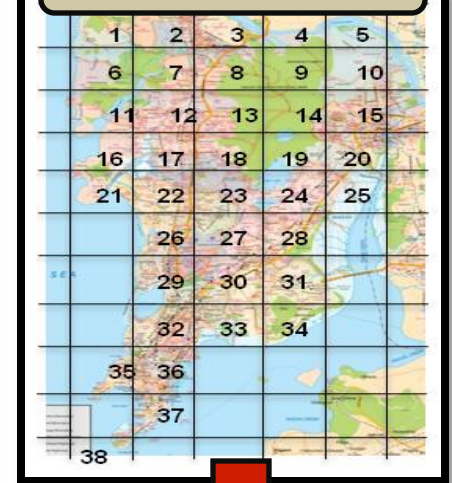
INDUSTRIAL SECTOR



SLUM SECTOR



RESIDENCIAL & COMERICAL SECTOR



- Vehicle Density count on roads
- Fuel type used, VKT
- Road length
- % of paved and unpaved roads

- Type of industries
- Fuel type used
- Fuel consumption
- NO. of industries

- Fuel consumption pattern
- Total consumption of fuel
- Hour of cooking
- No. of slum pockets

- Fuel consumption pattern
- Total consumption of fuel
- Hour of cooking
- No. of Hotels & Restaurants

Real data : Need has been fulfilled



Real data : Need has been fulfilled

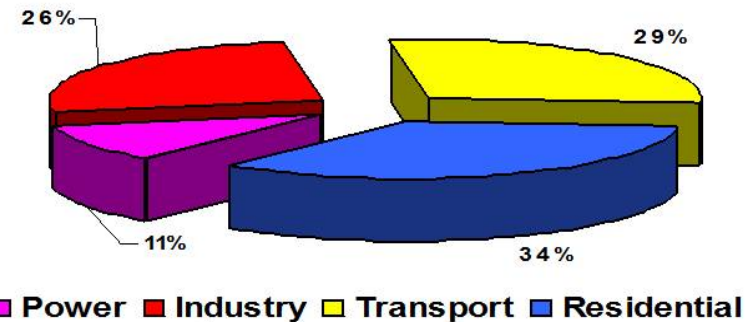




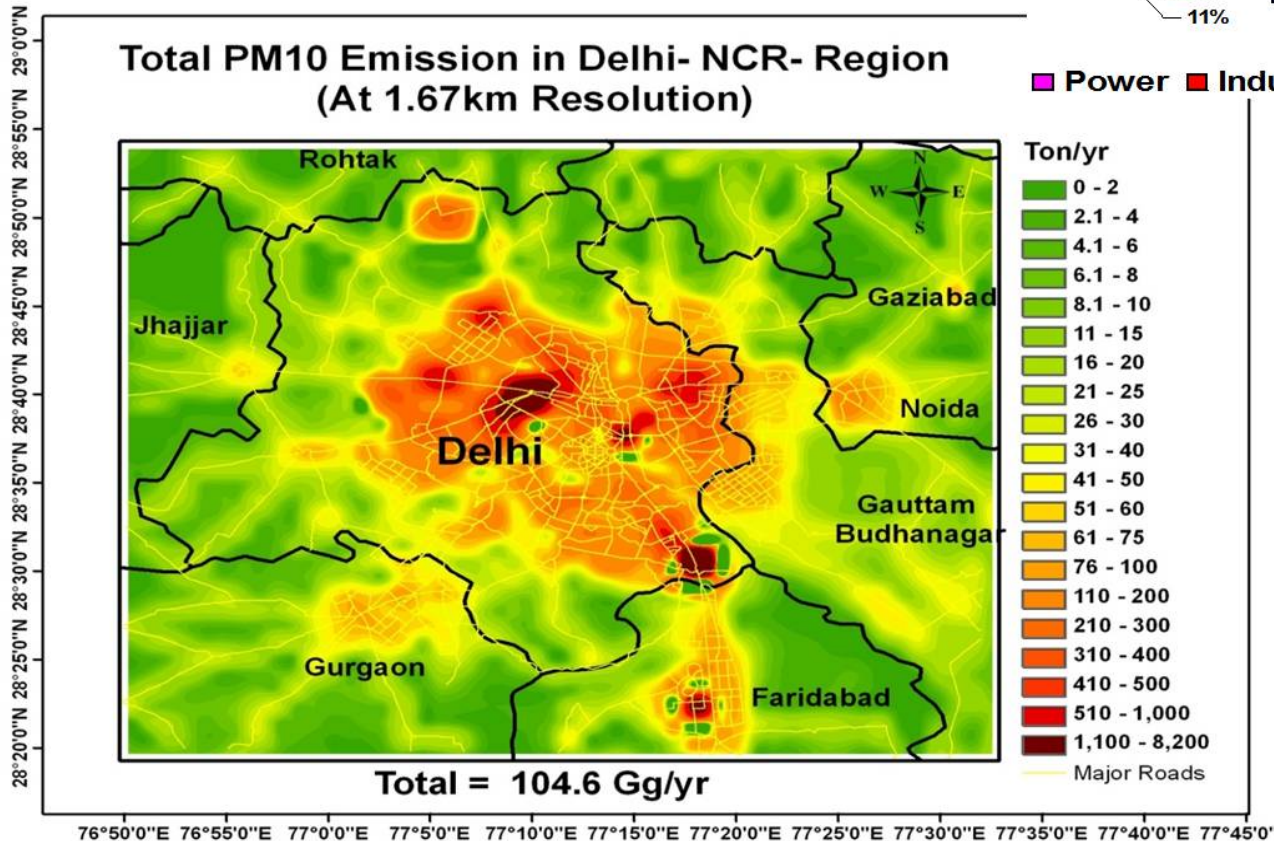
AIR POLLUTION HOT SPOTS

NCR-Delhi: PM10 INVENTORY for 2010

Relative Contribution of PM10 Emission from Different Sectors in Delhi-NCR-Regions



Total PM10 Emission in Delhi- NCR- Region
(At 1.67km Resolution)

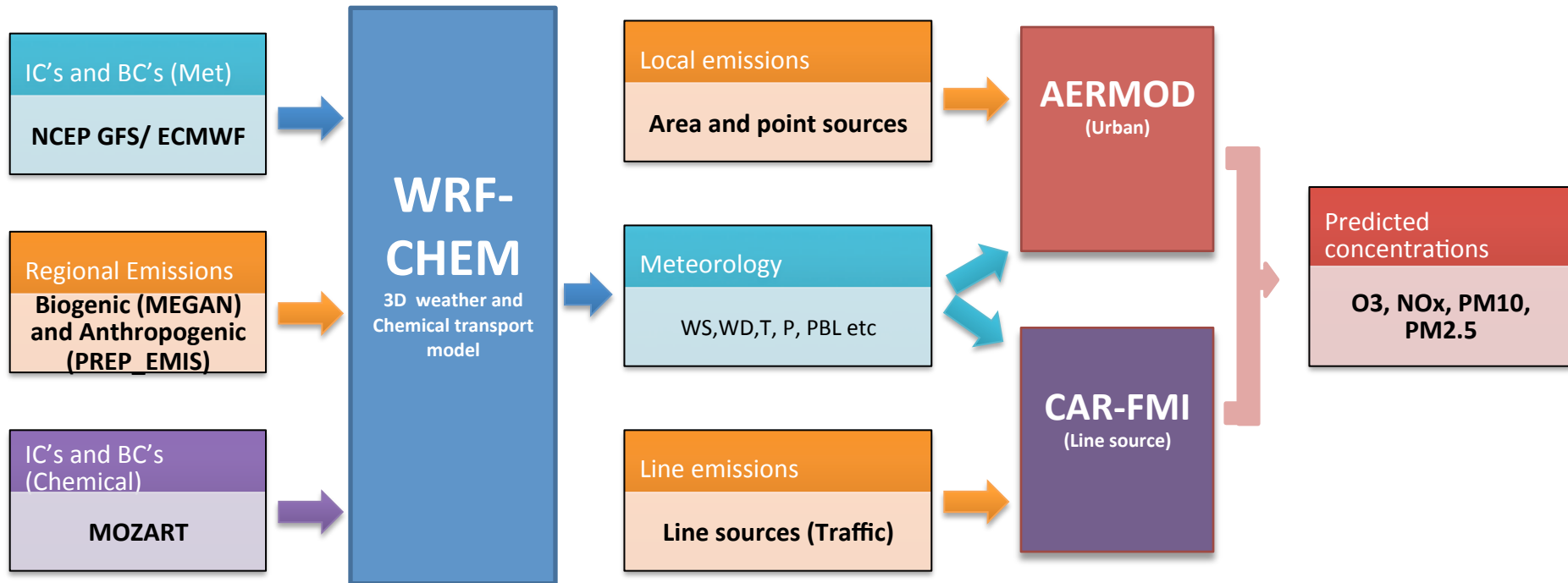


Quantify the contribution of various

Emission sources
(transport, industries, energy
and bio-fuel)
in deteriorating air quality and
climate.

Work towards unified country
specific chemical-climate
prediction system through
observations
and modeling capabilities.

Coupled Regional-Urban-line source modelling system



$$C_{\text{Total}} = C_{\text{Regional}} + C_{\text{Urban}} + C_{\text{Road}}$$

IMPROVE FORECASTING SKILLS

**Fastest super
computer in Pune**

Coarse Domain

TWO WAY NESTING

Domain 1

Domain 2

Domain 3

Fine Domain

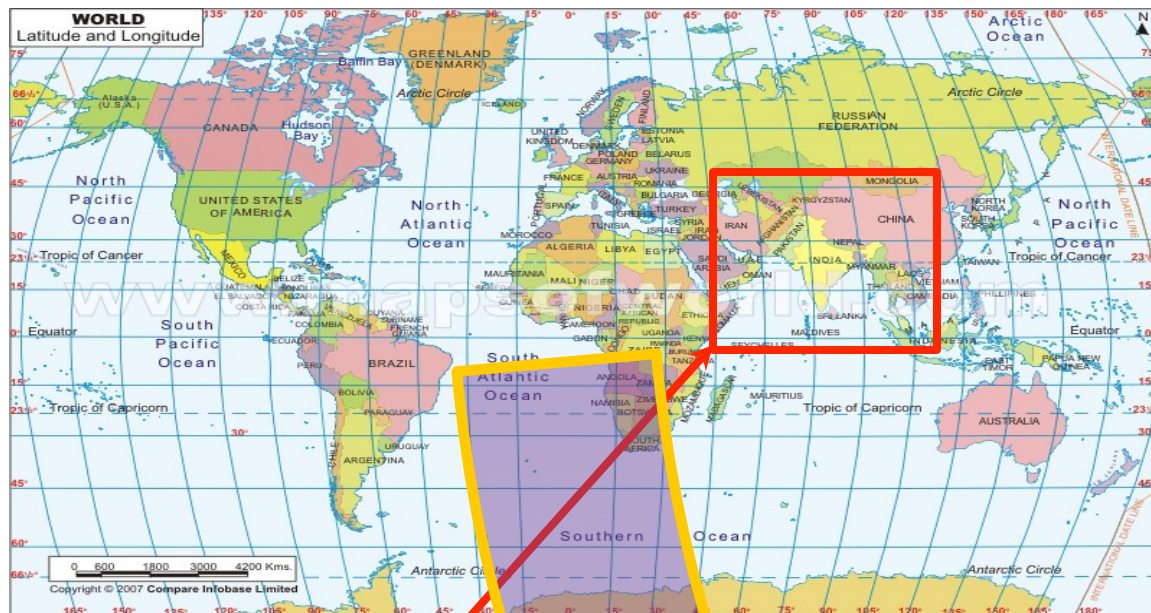
Domain 4
Mumbai

Meteorology

FEEDBACK

Aerosol

SAFAR- Delhi FORECAST Model:



Domain 1



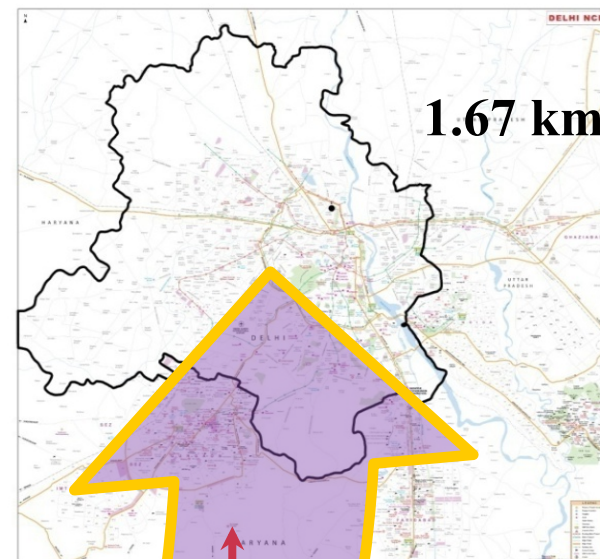
45 km

Domain 2



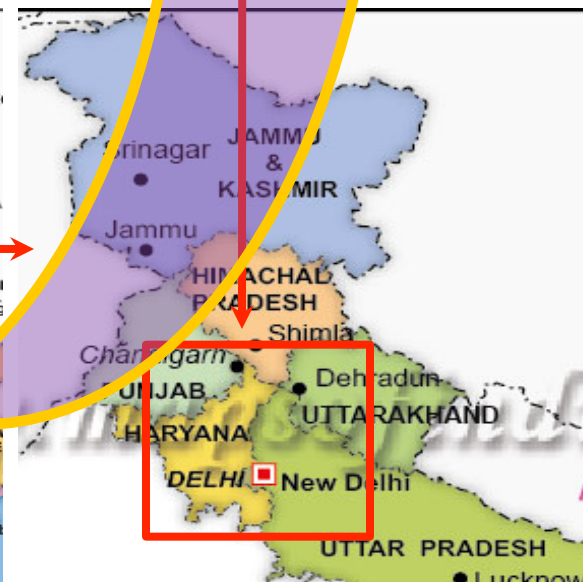
15 km

Domain 4



1.67 km

Domain 3



5 km

Boundary Conditions

CHEMISTRY & METEOROLOGY

```
#!/bin/bash
LINK=$(wget "http://ows-server.iek.fz-juelich.de/MACC_fnyp_fc-3hourly_ModelLevel?
service=WCS&Request=getcoverage&version=1.1.2&BoundingBox=40,-10,130,60,urn:ogc:
def:crs:OGC:2:84&format=application/x-netcdf&store=true&identifier=MACC_20130301" -
O - | grep "xlink:href=" | cut -f 2 -d\)
wget ${LINK}
```

<http://www.nco.ncep.noaa.gov/pmb/products/gfs>

Run Stars at 12:12 PM, Runtime:21Hrs, Final Output: 10:00 AM



Monitoring atmospheric composition & climate

mac3 Monitoring atmospheric composition & climate

opencircus

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Home >

LATEST Poor air quality over Western Europe

User Support
Documentation
Validation
E-learning of
Mailing Lists
Operational Info

Services
Air Quality & Atmospheric Composition
Climate Forcing
Ozone Layer & Ultra-Violet Radiation
Solar Radiation
Emissions & Surface Fluxes

Air Quality and Atmospheric Composition

Climate Forcing

Ozone Layer & UV

Solar Radiation

Emissions and Surface Fluxes

In Focus: User Workshop

14 April 2015 On 11 May MACC-III is organizing, in collaboration with the Italian user community, its next User Workshop. The meeting will take place in Rome and will consist of presentations from both MACC-III representatives and MACC-III users. More information and registration can be found on the [events page](#).

Potential users of MACC-III are invited to complete the questionnaire at this link

MACC-III is a Coordination & Support Action (2014-2015) funded by the European Union under the Horizon 2020 Programme. It is coordinated by the European Centre for Medium-Range Weather Forecasts and operated by a 36-member consortium.



NATIONAL CENTRE FOR MEDIUM RANGE WEATHER FORECASTING

EARTH SYSTEM SCIENCE ORGANIZATION

MINISTRY OF EARTH SCIENCES

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About NCMRWF

Products

Observation Monitoring Report

Observed Rain

NCMRWF Model Data

RTI Act

Citizen Charter

Results Framework Document (RFD)

Vacancies

Recruitment Results

Telephone Directory

Events / Workshops

PROWESS 2014 Verification Workshop 2014

Reports

Publications

Reports

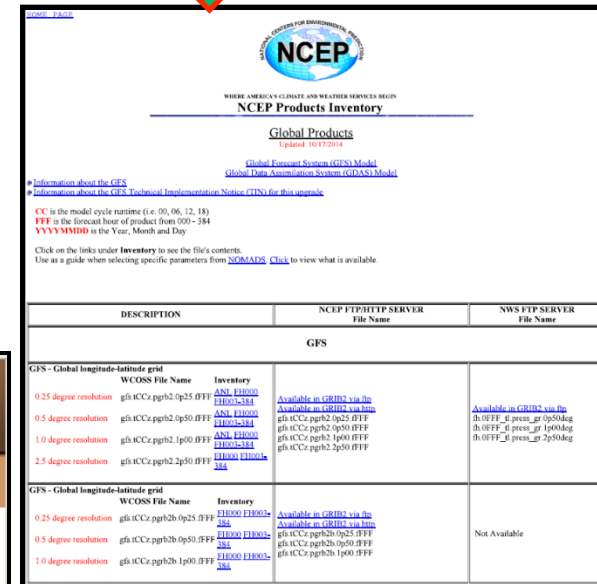
Official Tour Details

Other Links

Scientists Email

Web Administrator

The National Centre for Medium Range Weather Forecasting (NCMRWF) is a Research Institute under the Ministry of Earth Sciences and Climate Modelling under the Ministry of Earth Sciences. The Centre is to continuously develop forecasting systems, with increased reliability and accuracy, covering all regions through research, development and applications, maintaining highest level of knowledge, skills and technical bases.



NCEP

WHERE AMERICA'S CLIMATE AND WEATHER SERVICES BEGIN

NCEP Products Inventory

Updated: 10/17/2014

Global Products

[Global Forecast System \(GFS\) Model](#)
[Global Data Assimilation System \(GDAS\) Model](#)

Information about the GFS
Information about the GFS Technical Implementation Notes (TIN) for this upgrade

CC is the model cycle runtime (i.e. 00, 06, 12, 18)
FFF is the forecast hour of product from 000 - 384
YYYYMMDD is the Year, Month and Day

Click on the links under **Inventory** to see the file's contents.
Use as a guide when selecting specific parameters from [NCMATES](#). Click to view what is available.

DESCRIPTION	NCEP FTP/FTP SERVER File Name	NWS FTP SERVER File Name
GFS		
GFS - Global longitude-latitude grid	WCOSS File Name	Inventory
0.25 degree resolution	gfs ICCr.pgrb2.tp25.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
0.5 degree resolution	gfs ICCr.pgrb2.tp50.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
1.0 degree resolution	gfs ICCr.pgrb2.tp100.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
2.5 degree resolution	gfs ICCr.pgrb2.tp250.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
GFS - Global longitude-latitude grid	WCOSS File Name	Inventory
0.25 degree resolution	gfs ICCr.pgrb2b.tp25.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
0.5 degree resolution	gfs ICCr.pgrb2b.tp50.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
1.0 degree resolution	gfs ICCr.pgrb2b.tp100.0.FFF	Available in GFS102 via ftp Available in GFS102 via http
		Not Available

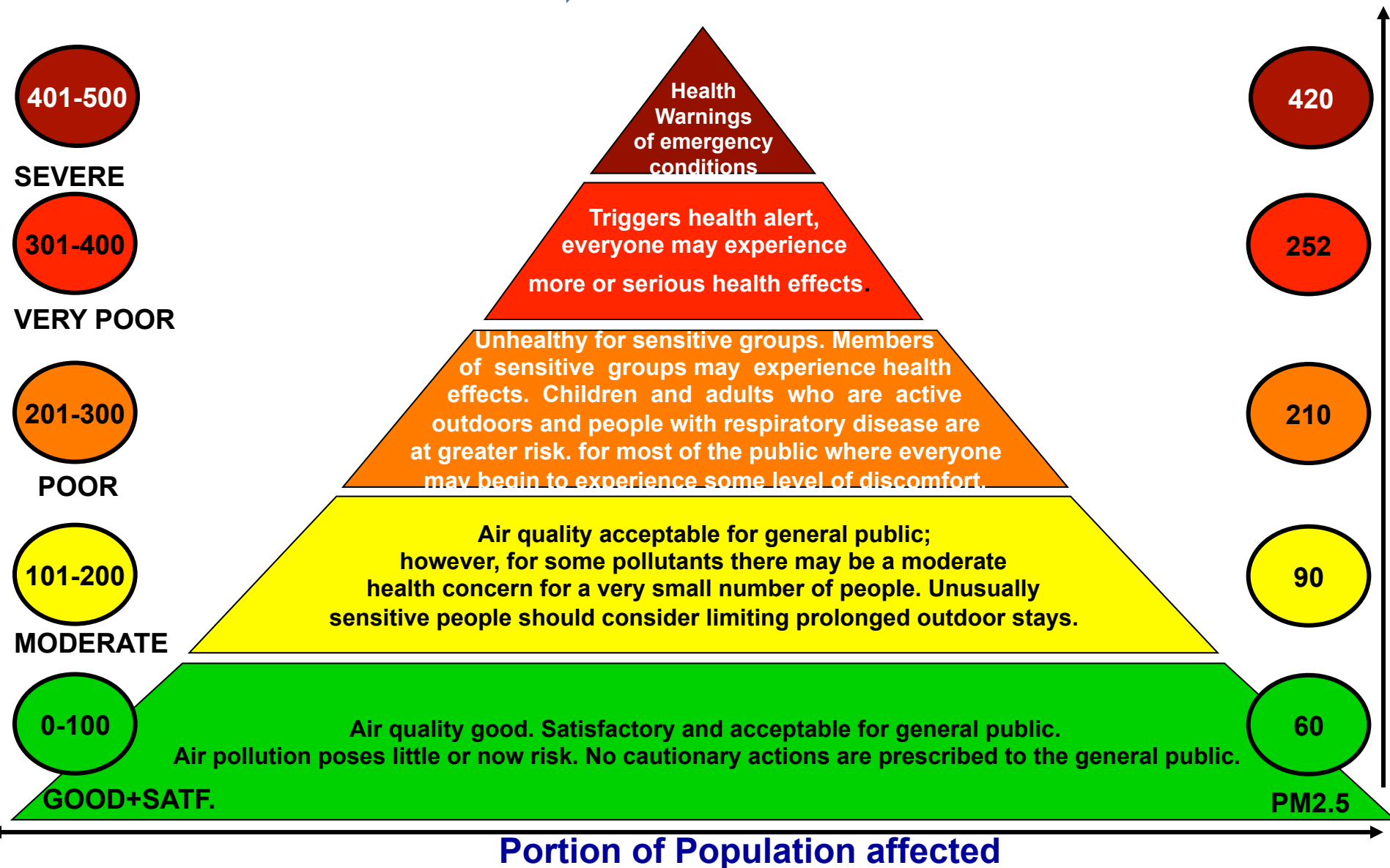
Awareness

*Sharing Knowledge with
Citizens /Students,....*

AQI?

Air Quality Index (AQI) is a rating scale used for reporting the quality of air we breathe in and the associated health effects

AQI → Health Advisories



Communicate to Public : Your MOOD → Stress Level



Convert science in to common language – **Numbers**, **Colours**, **Cartoons**
Issue **advisories** based on data

KNOW AIR QUALITY & WEATHER IN YOUR CITY



HOW?

COMMUNICATION MEDIA



WEB-PORTAL
safar.tropmet.res.in



TOLL FREE NO.
1800 180 1717



LED SYSTEM
Digital Display Boards



MOBILE APP
SAFAR-AIR



E-Mail: ALERT FOR EXTREME AIR POLLUTION AND WEATHER CONDITION

“Mobile App” Released on 17th Feb 2015 (14000 downloads so far)

SAFAR-Air

MOBILE APP



(Data on your tips)

Indian Metro Air Quality Service-SAFAR

(ESSO, Ministry of Earth Sciences, Govt. of India)

Central Delhi

Tue, 17 February

AQI : 255

PM2.5



Good

Moderate

Poor

Very Poor

Critical

Health Advisory: Sensitive people may experience health; effects. The general public is less likely to be affected.

[More Info..](#)

Tomorrow's Forecast

AQI : 310

PM10



Good

Moderate

Poor

Very Poor

Critical

Health Advisory: Sensitive people may experience health; effects. The general public is less likely to be affected.

[More Info..](#)

Service@IITM-IMD



Cities



AQI



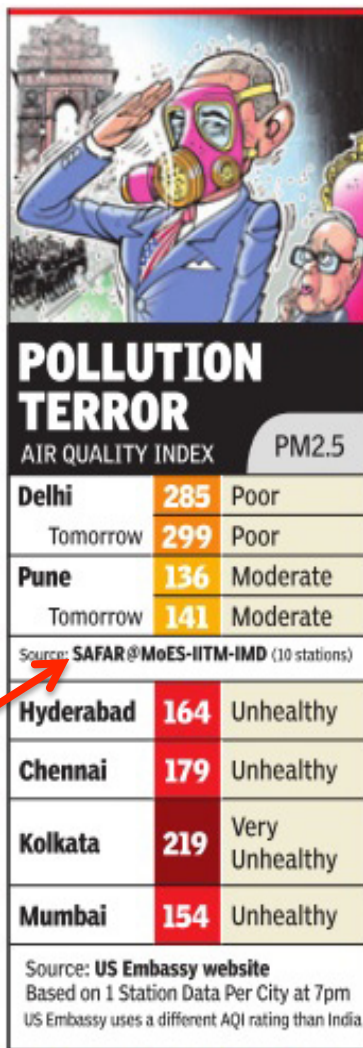
Refresh



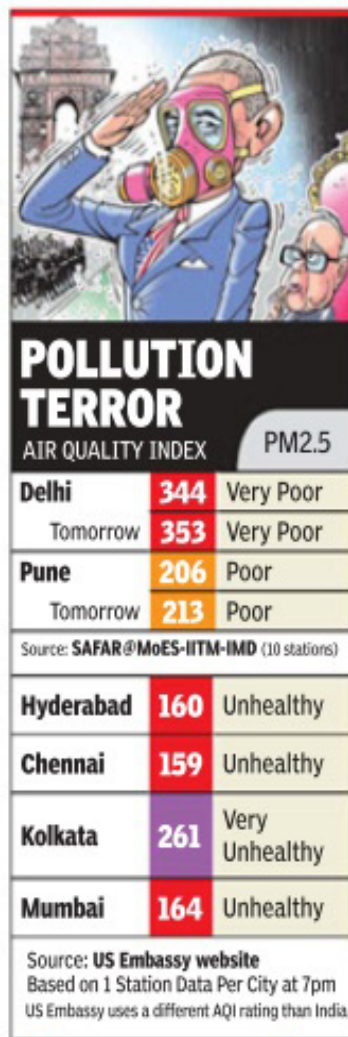
About



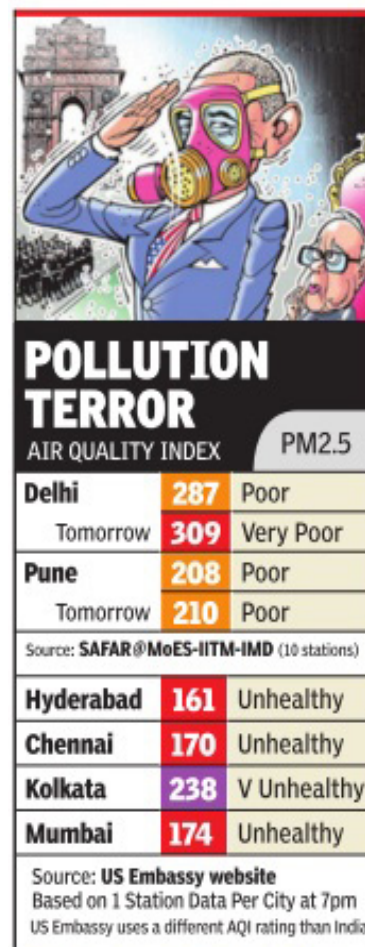
Close



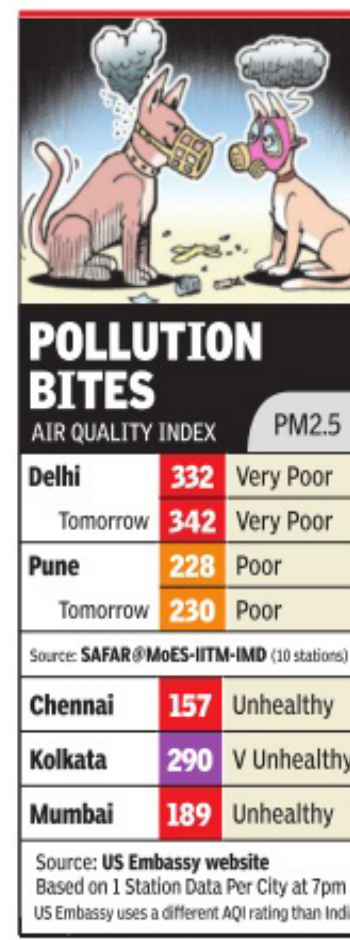
28-Dec-2014



29-Dec-2014



30-Dec-2014



31-Dec-2014

GAW Report No. 217

System of Air Quality Forecasting and Research (SAFAR - India)



WORLD METEOROLOGICAL ORGANIZATION GLOBAL ATMOSPHERE WATCH

GAW Report No. 217

SYSTEM OF AIR QUALITY FORECASTING AND RESEARCH (SAFAR-INDIA)

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Gufran Beig

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Sarita Yadav and Hanumant K. Trimbake
Indian Institute of Tropical Meteorology, Pune, India

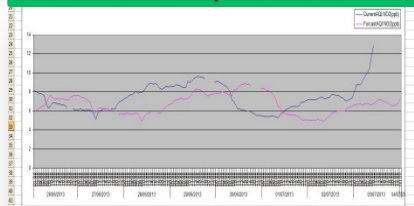


June 2015

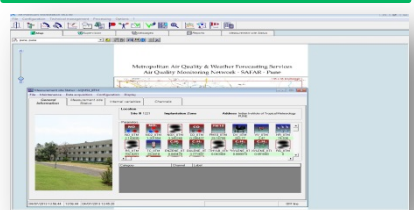
Metropolitan Air Quality and Weather Forecasting Service SAFAR-Master Control Center, IITM, Pune



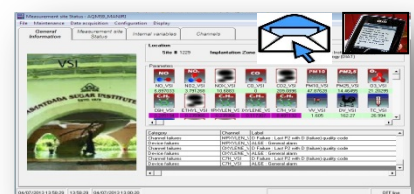
Forecast- Real Data Compare



Current status of AQMS & AWS



Alerts



Current status of DDS



AQI & UVI



DIGITAL DATA WAREHOUSE

Atmospheric Pollution & Climate Change

SAFAR-Pune Implemented on
1st May 2013

<http://safar.tropmet.res.in/cityname>
<http://envis.tropmet.res.in>

ONE

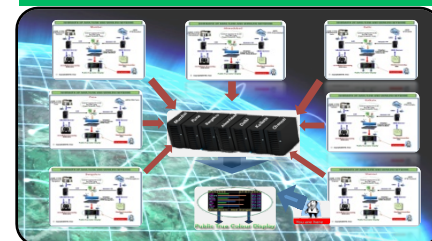


SHOP

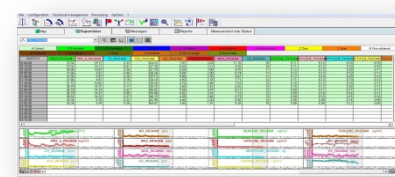
- Numerical Data Base
- Non- numerical Data Base
- Descriptive information

- Air Quality Online
- GIS-Based visualization
- AQ Extreme Events
- Bibliography

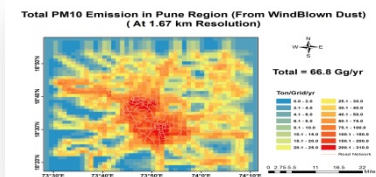
AQMS and AWS Network



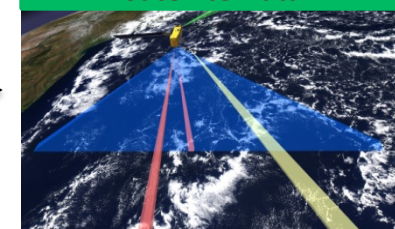
Historical Data



Emission Scenario



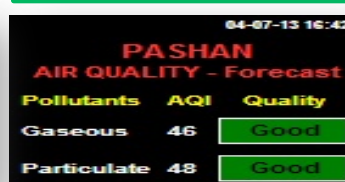
Satellite Data



Weather Tomorrow



Air Quality Tomorrow



Dynamic Web portal

